TAP 501- 3: Quanta

Speed of electromagnetic radiation in free space (c) = 3.00×10^{8} m s^{-1}

Planck's constant (h) = 6.63×10^{-34} J s

1. Write down the equation for the quantum energy of a photon in terms of its frequency.

2. Calculate the energies of a quantum of electromagnetic radiation of the following wavelengths:

(a)	gamma rays	wavelength	10^{-3} nm
(b)	X rays	wavelength	0.1 nm
(c)	violet light	wavelength	420 nm
(d)	yellow light	wavelength	600 nm
(e)	red light	wavelength	700 nm
(f)	microwaves	wavelength	2.00 cm
(g)	radio waves	wavelength	254 m

3. Calculate the wavelengths of quanta of electromagnetic radiation with the following energies:

(a) 6.63×10^{-19} J

(b) 9.47×10^{-25} J

(c) 1.33×10^{-18} J

(d) 3.98×10^{-20} J

Practical advice

Pupils may need to be reminded that a wavelength of 10^{-3} nm is 1×10^{-12} m and that some students could need help in using their calculators.

Answers and worked solutions

1 $E = hf$

2

(a) $f = c/\lambda$ $E = hf$ so $E = h\,c/\lambda$

$E = (6.63 \times 10^{-34} \times 3 \times 108) / (1 \times 10^{-12}) = 1.99 \times 10^{-13}$ J

(b) $E = 1.99 \times 10^{-15}$ J

(c) $E = 4.74 \times 10^{-19}$ J

(d) $E = 3.01 \times 10^{-19}$ J

(e) $E = 2.84 \times 10^{-19}$ J

(f) $E = 9.95 \times 10^{-24}$ J

(g) $E = 7.83 \times 10^{-19}$ J

3

(a) $\lambda = hc/E$ $\lambda = (6.63 \times 10^{-34} \times 3 \times 108) / 6.63 \times 10^{-19} = 3 \times 10^{-7}$ m (300 nm)

(b) 0.21 m

(c) 1.5×10^{-7} m (150 nm)

(d) 5×10^{-6} m